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J. H. GEHRMANN

A COMPARISON OF REDUCTION AND INCINERATION SYSTEMS OF GARBAGE DISPOSAL

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A COMPARISON OF REDUCTION AND INCINERATION SYSTEMS OF GARBAGE DISPOSAL

BY

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A THESIS SUBMITTED FOR
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Garbage disposal in American cities has in the past often been considered as a matter of convenience, but now it is considered absolutely necessary. In the last twenty years great strides have been made with the question. Many systems of disposal have been proposed and tried; some have been successful enough to last, and some have been found to be infeasible. During the twenty years of the evolution of the present systems, the engineers drawn into the field have left different solutions for the garbage problem. In the early days of the problem, plans applicable to all cities were proposed. Today each plan is for one city, or some special group of cities. Of course, data relating to the various systems becomes of great value if it is used with discrimination.

In order that the terms used be not confused, the following definitions are to hold throughout the discussion:

"Garbage" - All organic waste or residue of animal, fruit or vegetable origin, and any matter or substance used in the preparation, cooking, dealing in, or storage of meats, fowls, fruits, or vegetables.

"Rubbish" - All discarded and useless matters from residences and places of business not classified as garbage or ashes; such as paper, straw, excelsior, rags, bottles, old clothes, shoes, tin cans, etc.

"Street Refuse" - Street sweepings, dead animals, and snow.

"Trade Refuse" - Material from building construction, stable manure.

It is not only necessary to consider the disposal of garbage but also the disposal of the other wastes, such as ashes, rubbish,

street and trade refuse. The classification on Page 3 is designed to show the wide variety of material which must be considered in the design of a satisfactory system of city waste disposal.

From this classification it is seen that garbage is only a small part of city waste; yet it is the most important part. Ashes, rubbish, and trade waste may be kept indefinitely without causing unsanitary conditions. If garbage is kept any length of time, varying from two days in summer to a week in winter, it becomes a great menace from a sanitary viewpoint. Dr. Reynolds says,[1] "I am in favor not only of separating ashes and garbage, but of separating garbage from all other wastes, and collecting it and disposing it distinct and separate from every other form of waste. Ashes, paper, and all other such waste may lie upon the street, in the alley, or in the yards of a city without doing any positive harm from a sanitary standpoint, while putrifying garbage is always a distinct menace. When garbage is left to decay it furnishes food for rats, mice, flies, and other vermin; all of which are a pest. With our present knowledge of the part played by insects and vermin in spreading disease, the attention of the sanitarian must be turned to their destruction, and I know of no better way to destroy them than to take away the food upon which they live. This food is chiefly garbage and manure."

Several years ago the generally accepted view was that garbage was a source of disease producing bacteria. Today, those who have made a study of the question, say that garbage is not a source of disease producing bacteria, but that it is a source of food and a breeding place for the cariers of disease.

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1 - Engineering News, Feb. 1901.

- City waste
  - Sewage
    - Liquid and semi-liquid refuse
      - House sewage
      - Street, roof, and area drainage
      - Night soil
  - City Refuse
    - Household Refuse
      - Garbage
        - Animal matter
        - Vegetable matter
        - Meat and bones
        - Fruit
      - Ashes
        - Steam
        - Household
      - Rubbish
        - Paper
        - Wood
        - Rags and bedding
        - Leather and rubber
        - Metals
        - Bottles and glass
        - Crockery
        - Sweepings from buildings
    - Street Refuse
      - Street Sweepings
        - Animal manure
        - Pavement dirt
        - Droppings from coats
        - Materials from building construction
        - Rubbish and leaves
      - Dead animals
      - Snow
  - Trade Refuse
    - Cellar excavations
    - Material from building construction
    - Stable manure
    - Market offal
    - Slaughter-house offal
    - Dead animals

Mr. C. O. Bartlett, in his paper on "City Garbage" read before the Cleveland Engineering Society in March 1914, takes the following as an average proximate analysis of household refuse - not considering ashes - and the other available data approximates this.

Rubbish	6%
Water	75%
Tankage	15%
Grease	4%

This average is taken from data given in the reports of some of the larger cities, including New York, Philadelphia, Cleveland, Columbus, Chicago, Milwaukee, and Minneapolis. The following results were obtained from New York City waste according to a report in the Journal of the Association of Engineering Societies for 1909.

	Water	Vol.Matter	Carbon	Ash
Garbage	73.26%	16.89%	4.71%	5.14%
Coal and Cinders	1.34	3.73	55.00	39.93
Fine Ash (screened)	1.20	4.02	17.38	77.40
Rubbish	5.78	65.66	14.69	13.87

An elementary analysis of dry garbage as given in the Proceedings of the American Society of Civil Engineers for 1908, was as follows:

Carbon	43.10%
Hydrogen	6.24
Nitrogen	3.70
Oxygen	27.74
Silica	7.56
Fe_2O_3 Al_2O_3	6.41
Lime	4.26
Mg O	0.28
Phosphoric acid	1.47
CO	0.59
PbS Sns	0.20
Alkali and Undetermined	4.45

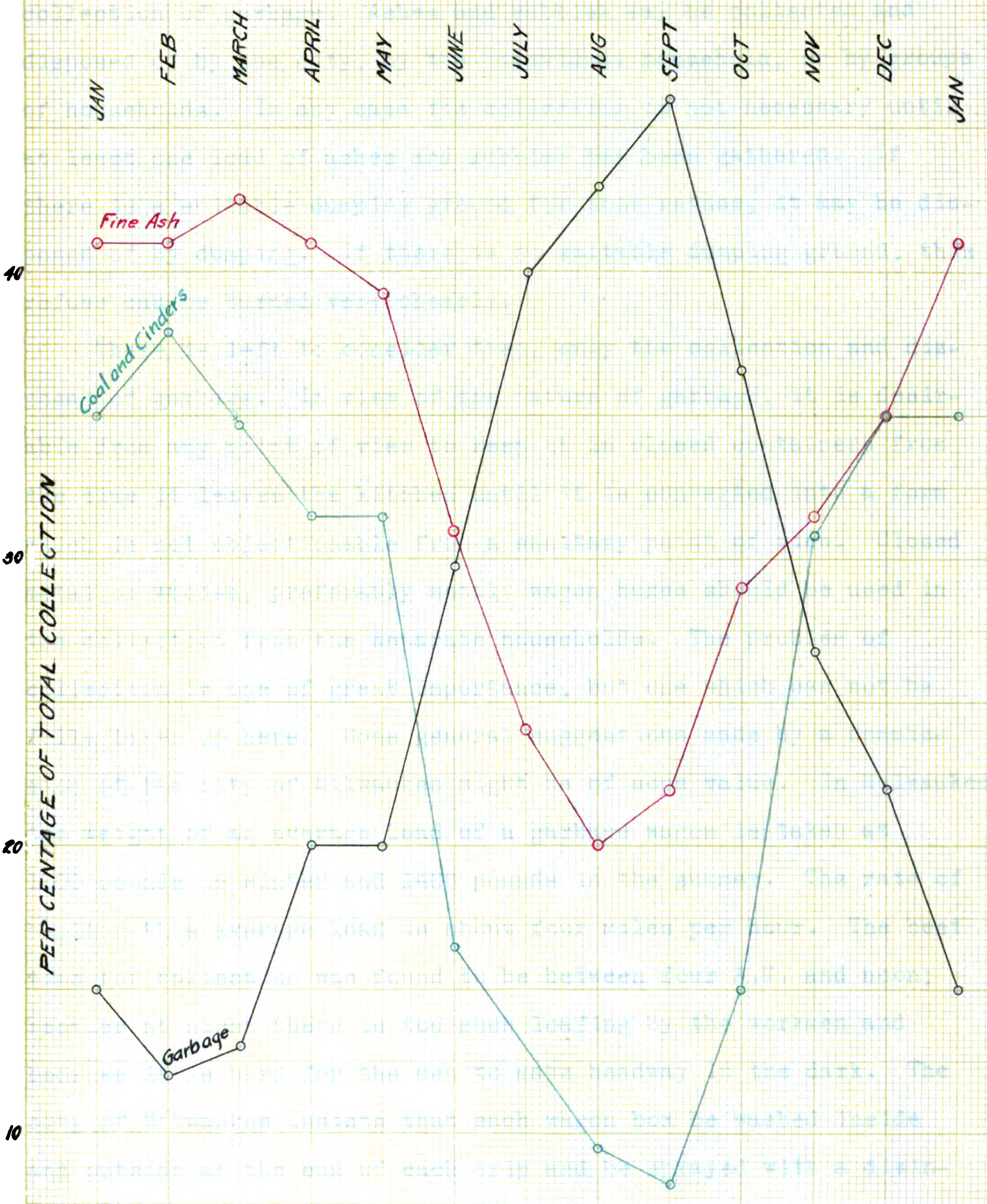
The variable percentages of the different constituents in waste are due to many causes. Some of the most important variations are caused by:

(1) The effect of the time of year.
(2) Climatic conditions.
(3) Geographic conditions.
(4) Nature of the food consumed by the people.
(5) Crop successes and failures.
(6) Habits of the people.

This is shown by the following data and the chart on the next page.

Month	Cleveland	Columbus	Cincinatti	Washington	New York	Detroit	Chicago
January	7.00%	6.28%	5.34%	7.50%	6.30%	7.30%	5.50%
February	6.00	5.67	5.20	6.60	5.70	5.85	5.30
March	7.80	6.36	5.16	7.20	7.00	6.60	5.30
April	7.85	6.70	6.92	7.55	8.10	7.55	6.50
May	7.50	7.78	7.80	8.45	9.25	8.20	7.40
June	9.00	7.82	9.08	7.80	9.37	7.90	8.10
July	8.65	9.40	12.40	9.20	9.55	8.80	10.50
August	9.60	12.24	12.10	11.70	9.86	10.40	12.40
September	10.70	12.95	13.80	10.90	10.89	10.10	12.30
October	9.80	9.20	8.20	8.50	9.18	10.30	10.60
November	8.30	7.83	7.50	7.40	7.80	8.10	8.60
December	7.60	7.77	7.50	7.20	7.00	8.90	7.50
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

It has been shown that the best sanitary conditions can only be obtained by a separation of the garbage from the ashes and other household waste. Collection of household waste will then take place in two parts: the collection of ashes and rubbish and the



Monthly Variation of the Principal Constituents of Household Waste by Weight - West Brighton, New York. 1904-06.

collection of garbage. Ashes and rubbish may be collected and disposed of by the city, by the individual household, or by groups of households. In any case the collection is not necessary until at least one load of ashes and rubbish has been gathered. If there is a suitable dumping ground for this refuse, it may be disposed of by dumping. If there is no suitable dumping ground, this refuse can be burned very cheaply.

There is left to consider then, only the collection and disposal of garbage. In view of the nature of garbage, it is desirable from any point of view to keep it in closed containers from the time it leaves the kitchen until it is converted into a form which is not objectionable from a sanitary point of view. Closed metal or wooden, preferably metal, wagon boxes should be used in the collection from the separate households. The problem of collection is one of great importance, but one which can not be fully taken up here. Some general suggestions made by a commission of the city of Milwaukee might be of some value. In Milwaukee the weight of an average load of a garbage wagon is taken at 1200 pounds in winter and 1400 pounds in the summer. The rate of hauling this average load is about four miles per hour. The best time for collection was found to be between four A.M. and noon; because at night there is too much loafing by the workmen and because it is hard for the men to make headway in the dark. The city of Milwaukee insists that each wagon box be washed inside and outside at the end of each trip and be sprayed with a disinfectant at least one a week. Each collector is made responsible for the district which he covers, and for the condition of his wagon.

If the disposal is carried on outside of the town the gar-

bage is usually hauled to the place of disposal on cars or on boats. The treatment depends on the type of disposal system used. The chart on the following page taken from a report by J. W. Alvord on "Garbage Disposal Systems" - Engineering and Contracting, 1911 - shows the applicable methods of refuse disposal. The data was compiled in 1910 and is subject to correction due to the improvements of the different systems of disposal.

GARBAGE DISPOSAL SYSTEMS.

J. W. Alvord

Enginnering and Contracting. July, 1911.

Garbage and Organic Waste (capable of combustion)

A. Primitive

1 - Feeding Swine
2 - Fertilizer (direct)
3 - To dumping grounds
4 - In rivers (where available)
5 - At sea (where available)

B. Scientific

1 - Burial in layers promptly covered
2 - Cremation of garbage alone
3 - Incineration with ashes
4 - Reduction

Rubbish (largely combustible)

1 - To dump
2 - For filling
3 - Dumped in rivers
4 - Dumped in sea
5 - Sorted and burned
6 - Cremation with garbage
7 - Incineration with total refuse

Ashes and Inorganic Waste (containing combustibles)

1 - Filling
2 - Dumping at sea
3 - Incineration

The different systems listed in the report may be described and considered as follows:

"Feeding Swine" - The garbage is fed in an untreated condition to swine. This system naturally can only be used in small communities not exceeding forty thousand population. This system is open to very serious objection because much of the raw garbage is not fit to feed swine. Without a bacteriological examination of each load of garbage this system is extremely dangerous.

"Use directly as a fertilizer" - In this system the garbage is spread on free ground and is plowed under. In very small communities this can be done, but when there is a large quantity of garbage to dispose of the area necessary is not available, especially in summer when there is the greatest need for quick disposal. In the cold climates this system is obviously impossible in winter.

"Dumping Grounds" - The garbage is taken out to some vacant spot and dumped along with the ashes and rubbish. This is a very unsanitary and objectionable method. A garbage dump in very little time becomes infested with all types of vermin.

"Dumping in Rivers and in the Sea" - This is possible only in cities situated near water. The government has prohibited dumping in navigable streams, because there is a tendency for garbage to collect in the channel and form the foundation for sandbars. It is also unsanitary. Dumping in the sea, within limits which are economically available, has been declared unsanitary and is usually prohibited.

"Burial" - This method is available only in communities which have large areas to be filled in and have available ground with which to cover the garbage. It is a sanitary method so long as

the garbage is immediately covered with a fairly thick layer of earth. The main trouble with this system is that it is only a temporary relief. As soon as the available area is filled, another system of disposal is necessary. In most cases the increased value of the filled land is sufficient to pay for the cost of collection and burial. This system is now being used with success in Davenport, Iowa, but in about ten years all the available ground will have been filled in and another system of disposal will be required.

INCINERATION.

Incineration is one of the popular forms of garbage disposal. In this system the garbage, ashes, and rubbish are burned in specially constructed burners. On account of the high percentage of moisture in garbage it is necessary to mix in at least forty-five percent of rubbish and ashes to provide the necessary combustible matter. The committee which investigated the Milwaukee incinerator recommends a mixture of fifty percent garbage and fifty percent rubbish and ashes.* During the summer months when the amount of garbage increases and becomes greatly in excess of the rubbish and ashes, it is necessary to add some other fuel to burn the garbage properly. This extra fuel must be bought. Hence, during the period when the amount of garbage to be burned is greatest, the expense of disposal is also the greatest.

The claims made for the incineration of garbage are:

1 - That incineration destroys all germs, odors, and organic matter.

2 - That unskilled labor can be used.

3 - That district incinerators are possible, and hence the process can be made very economical.

4 - That no separation of the refuse is necessary.

5 - That incineration is more economical than reduction.

The claim that incineration destroys all odors is not supported by evidence available. Under the present practice odors are always present in the neighborhood of an incinerator. It is possible that later improvements will do away with these objection-

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* - Bulletin #5, Milwaukee Bureau of Efficiency and Economy.

able odors but these improvements will tend to be very expensive. At present, the garbage is unloaded and kept in bins until it can be burned. These bins are necessarily open, and the odor of the raw garbage in various stages of decomposition escapes into the atomosphere. Then, too, if the fires are not kept in good condition,incomplete combustion,and objectionable odors from the stack will result.

The claim that unskilled labor can be used is of no importance because there is no other system of garbage disposal which requires skilled labor. The average daily wage of the laborers in the incinerator in Milwaukee in 1909 was two dollars. The average daily wage of the laborers in the Cleveland reduction plant for the same year was one dollar and seventy-eight cents.* Since reduction is the only other method of disposal in use in the larger cities of the United States, it is the one which will be used for the sake of comparison.

The claim is that district incinerators are possible. The district incinerator plan was proposed by an engineer who wished to reduce the length of the wagon haul from the individual household to the disposal plant. This plan materially decreases the length of the haul, but it also increases the cost of disposal. It is obviously much cheaper to build one plant and dispose of all the garbage in one building, than it is to build several plants and dispose of the garbage in small lots. In a large plant it is possible to use the heat from the burning garbage to generate steam but in small plants the cost of the equipment for the generation of steam is excessive. By means of a system of district receiving stations and one central plant, it is possible to reduce

* - U. S. Census Report - Statistics of Cities in 1909.

the expensive wagon haul by increasing the comparatively inexpensive train haul. The value of the steam that could be generated at this one central plant should more than counterbalance the increased cost of haul, and the lower first cost and lower overhead charges on the single plant should be a direct saving. There is at present no available data for this comparison.

The claim that no separation of refuse is required has already been shown to be false; a separation of refuse is essential for sanitary purposes. Colonel Waring, sanitary engineer of New York City, recommended that garbage be separated from the other refuse for sanitary reasons. Colonel Waring is one of the foremost advocates of the incineration system. Practically all of the important cities of England and Germany require the separation of household refuse. Milwaukee and Saint Paul also require that the garbage be delivered to the incinerator separate from the rubbish and ashes.

The most serious objection to the incinerator aside from the matter of cost, is that it wastes an excellent fertilizer material. According to a report in the May 1913 issue of the Municipal Journal, 535,000 tons of garbage were burned during the year 1912. This was an absolute destruction of about 75,000 tons of excellent fertilizer, and 21,000 tons of grease. The fertilizer and grease would have been worth about $1,890,000 at the prices quoted in the Spring of 1913.

CHEMICAL REDUCTION.

There are several different systems of chemical reduction, most of which consist in various methods of treatment of garbage with chemicals to extract the grease. Very little has been published about this system.

REDUCTION SYSTEM.

A good idea of the operation of a reduction plant can be obtained from the following description of the operation of the Columbus plant which has a daily capacity of 80 tons.

The garbage is weighed on railway track scales at the plant, and is then unloaded in the receiving building. By means of a car dumping device mounted on trunnions the contents of the car are dumped on the floor below. A scraper conveyor picks up the garbage and carries it to the top of the reduction building. Here it is charged into the digestors, which are large steel tanks capable of holding from ten to twelve tons of garbage.

The digestors are filled and sealed. As soon as the seals are tight, steam is admitted at the bottom of the digestors and the garbage is cooked for several hours. The time required to thoroughly cook out the grease varies with the quality of the garbage. Any odors or gases escaping from the digestor through the pressure regulating valve are passed through condensers or into deodorizing furnaces. After the garbage is thoroughly cooked, it is discharged into a receiving hopper which is also completely sealed. From this hopper the garbage is mechanically discharged into a roller press. As the wet material passes between the rolls, a great deal of grease and water is pressed out of it. The grease and water flow out of the rear of the press into catch basins. The solid material passes out of the front of the press into a conveyor to the dryers.

The grease and water are pumped from the catch basin into a set of tanks. Here the grease is separated from the water by gravity. The grease is drawn off into storage tanks, and the

tank water, from which the grease has been separated, is run into a triple effect evaporator where it is concentrated to a thick syrup. This syrup is mixed with the solid material after it has left the percolator and is ready for the final drying.

The solids from the press are fed into a continuous dryer of the direct heat type. The dried material is discharged into a conveyor which runs to the percolating building. The percolator, which has a capacity of about ten tons of solids or tankage, is filled from a hopper into which the conveyor has discharged the tankage. When the percolator is filled it is sealed and flooded with gasoline. The gasoline dissolves the remaining grease out of the tankage. The combined grease and gasoline are drawn off and discharged into distilling tanks. The gasoline is distilled off, condensed, and used over again.

After the gasoline and grease have been allowed to run out of the percolator, steam is passed through the tankage to vaporize the remaining gasoline. This gasoline passes off and is condensed in an ordinary air cooled condenser. From the condenser the gasoline is pumped into storage tanks and saved for future use.

The dry tankage is then screened to remove all rubbish and foreign material which may have passed through the process. After this screening, the concentrated tank syrup is mixed with the tankage and the material dried. The dried material, used for fertilizer, is then ready for shipment. The grease is sold to re-refiners, who recover from it commercial "red oil" and glycerine.

The advantages of the reduction system of disposal are:

1 - It is the only system in use today operating without a loss.

2 - It is a process which saves valuable material and changes it into a form in which it becomes of commercial importance.

3 - It is at present the most sanitary system.

4 - It is a system which becomes more economical with an increase in the supply of garbage, and hence there is an incentive to get all the garbage possible instead of trying to get as little as the people will demand.

That the reduction system of garbage disposal is an economical one is shown by the following: The Columbus, Ohio plant made a profit of about $1.24 per ton on all garbage disposed of in 1912; the Cleveland, Ohio,plant made a profit of $1.76 per ton in 1911; the city of Los Angeles receives $.51 per ton from a private concern for its garbage as delivered at the plant. Compare this with the results obtained by the Milwaukee incinerator which lost $2.90 per ton of garbage in 1911.* The reduction system also saves valuable materials and changes them into a form of commercial importance. The Columbus reduction plant sold $61,728 worth of products during the year 1912.**

Reduction is at the present time the most sanitary method of disposal. When the garbage reaches the plant it is immediately sorted and then put into the reduction tanks. From the time it reaches the reduction tank until it is turned out as odorless fertilizer and grease, it is not exposed to the air; and all of the

*- Journal Cleveland Engineering Society. 1914.
**- Report on Collection and Disposal of Refuse and Garbage. Department of Public Servåce, Columbus, Ohio.

odors due to the process are destroyed before they can get out of the plant. The odors are easily controlled in the reduction system because the whole process is carried on in closed vessels.

Because the reduction system is the only one that becomes more profitable with an increase in the supply of garbage, it is also the only system in which the best interests of the plant demand that all of the available garbage be collected. In the incineration system, for example, each ton of garbage destroyed costs about three dollars, and each additional ton increases the expense of disposal; hence there is no incentive on the part of the plant to demand complete collections. Garbage in remote districts is often not collected until complaints are lodged by the people discriminated against. A good example of this was found in the city of Madison, Wisconsin. A private contractor collected the garbage in this city and fed it to swine. In the Spring of 1915 and investigation showed that only about eighty percent of the garbage was being collected. The contractor thought that it was an "unnecessary expense" to collect the other twenty percent, because it was in remote districts where the people would rather dispose of their garbage privately than complain continually.

Of course there are also some objections to the reduction system of garbage disposal. Most of these objections have been raised by men interested directly in incinerators. It is interesting to note that those objections which used to be considered as most vital were based on suppositions or on ideas that have since been found to be false. The chief objections have been:

1 - The cost of the plant.

2 - The necessity of separating the garbage from the other refuse.

3 - The long hauls necessary in large cities.

4 - The uneconomical operation of small plants.

The cost of the reduction plant is usually considered to be the greatest objection to the system. Actual construction costs show that this objection must have been based on a supposition. For instance, a comparison of the following prominent municipal disposal plants shows the error.

City	Plant	Capacity per Day	Cost	Cost per Ton Capacity	Profit per Ton Garbage.
Milwaukee	Incinerator	112 tons	$212,000	$1,890	$-2.90 (deficit)
Columbus	Reduction	80 tons	180,000	2,340	1.24
Cleveland	Reduction	150 tons	232,108	1,550	1.76

Another objection to the reduction system usually brought up by incinerator salesmen, is that a separate collection of garbage and other refuse is necessary. It is true that a separate collection is necessary, but it is not true that this an objection to the system. This separation, according to the Proceedings of the Engineering Club of Philadelphia for July 1906, was required in all the larger cities of the world, whether the method of disposal was incineration or reduction. Colonel Waring, one of the foremost advocates of incineration, recommends that this separation be made. Mr. S. A. Greeley, superintendent of the Milwaukee incinerator, recommended to the city of Milwaukee that this separation be made. The city of Milwaukee, using the incineration system at the present time, requires that the garbage be delivered to the plant separately. Prof. F. O. Jordan, Prof. of

Bacteriology in the University of Chicago, also recommends the separation for sanitary purposes. These recommendations were made primarily because it is absolutely essential for sanitary reasons to keep the garbage in closed metal containers.* It is obviously impossible to keep the large amount of ashes which is produced between collections, in metal containers that can be handled by the collector. Most incinerator superintendents also insist upon a separation so that they can tell what percent of garbage they are burning in any mixture.

The third objection is that it is infeasible to have district reduction plants, and hence it is necessary to make long hauls to the central reduction plant. In the case of incinerators, district plants are feasible and short hauls are possible. But, as has been shown under the discussion of the incinerator, it is practically as cheap to have one large central plant, as it is to have several small plants with shorter hauls. The reason for this is that a more thorough recovery of the products is possible in a larger plant, and that the first cost and overhead charges in a single plant are less than in several small plants. The cost of hauling the garbage may also be decreased by having district stations. Then, too, district incinerators are only for use in large cities.

As has been shown under the discussion of the costs of operation of the reduction and incineration systems, there is a difference of about four dollars per ton of garbage between the two systems in large cities.

In the city of Cleveland, Ohio, the freight charge from the loading station in the center of Cleveland to the reduction plant

* - See Page 2.

at Willow - a distance of about ten miles - is fifteen cents per ton of garbage.* Deducting this freight charge from four dollars leaves a difference of three dollars and eighty-five cents in favor of the reduction system.

Until very recently it was generally supposed that the garbage reduction system was only applicable for cities of more than 100,000 inhabitants. In 1914, the C. O. Bartlett & Snow Company of Cleveland, Ohio, announced that they had perfected a system, and the apparatus, for the economical reduction of small quantities of garbage. It is cf course impossible to make a profit in a small town disposal plant, but they claim to be able to dispose of garbage in their small town reduction plants more cheaply than it can be disposed of in a small incinerator. At present there is no data in regard to reduction plants in cities of less than 30,000 inhabitants, and there is also no cost data for small incinerators. Since the city of Cleveland disposes of its garbage for approximately four dollars a ton cheaper than the city of Milwaukee does, it is plausible that there should be a slight difference in favor of a small reduction plant over that of a small incinerator.

Of the reduction plants now in operation, probably the most successful are the plants at Cleveland and Columbus, Ohio. Both of these plants are operated by municipalities. In 1909 there were ninety-four reduction plants in operation in seventy-nine cities of the United States, having over 30,000 inhabitants. Forty-six of these were for the reduction of dead animals only. The rest were for the reduction of garbage, although most of them utilized the dead animals.

* - Engineering News. November, 1911.

Forty-six of the forty-eight garbage reduction plants were privately owned. Only two of the reduction plants, the Cleveland and Columbus plants, were owned and operated by the municipalities. In 1909 there were only forty-eight incinerators in cities of over 30,000 inhabitants in the United States. Forty-three of these were municipal plants and five were private plants. A comparison of the distribution of the two types of plants is interesting. In 1909 there were forty-eight incinerators in the United States, with a combined daily capacity of 7,849 cubic yards of garbage, and a total annual comsumption of 527,857 cubic yards. In the same year there were also forty-eight garbage reduction plants with a daily capacity of 53,300 cubic yards of garbage and a total annual consumption of more than 2,346,700 cubic yards. A list of the cities using garbage reduction plants and of those using incinerators, follows:

GARBAGE REDUCTION PLANTS.

City	Population	Tons of Dead Animals Reduced	Cubic Yards Garbage Reduced Annually
New York	4,766,883	10,733	577,228
Chicago	2,185,283	3,187	186,536
Philadelphia	1,549,008	84	651,360
St. Louis	687,029	2,690	2,230
Boston	670,585	2,100	92,151
Baltimore	558,485	67	152,608
Pittsburgh	533,905	1,414	136,004
Detroit	465,766		50,260
Buffalo	423,715		50,564
Cincinatti	363,591	1,200	53,694
Newark, N. J.	347,469	505	38,706

City	Population	Tons of Dead Animals Reduced	Cubic Yards Garbage Reduced Annually.
Washington, D. C.	331,069	402	72,110
Indianapolis	233,650		48,000
Rochester	218,149	600	66,329
Syracuse	137,249	4	23,264
Patterson, N. J.	125,600		14,400
Dayton, Ohio.	116,577		15,891
Bridgeport	102,054		15,625
Reading	96,091		14,048
New Bedford	96,652	181	11,411
Wilmington, Del.	87,411		9,288
Utica	74,419		14,085
Harrisburg	64,186		16,500
Atlantic City	46,150		22,400
York, Pa.	44,750		12,000
Columbus	181,511	No Report	
Lowell	106,294	" "	
Peoria	66,950	" "	
East St. Louis	58,547	" "	
Salem	43,697	" "	
Fitchburg	37,826	" "	

INCINERATORS.

City	Population	Tons of Dead Animals Burned	Cubic Yards Garbage Burned Annually.
New York	One Borough		23,600
Milwaukee	373,857	98	61,928
Minneapolis	301,408	2	36,807

Incinerators.(continued)

City	Population	Tons of Dead Animals Burned	Cubic Yards Garbage Burned Annually
Los Angeles	319,198	88	48,667
Portland, Ore.	207,214	276	16,241
Scranton	120,867	3	8,155
Memphis	131,105	32	28,780
Richmond, Va.	127,628	41	9,759
Grand Rapids, Mich.	112,571	10	3,957
Lowell	106,294	Market wastes only	2,601
Spokane	104,402	473	27,280
Trenton	96,815	2	20,552
Camden	94,538	20	576
Dallas	92,104		16,425
Troy	76,813		1,083
Yonkers	79,803		26,100
Youngstown	79,066		7,702
Duluth	78,466		9,072
Houston	78,800		51,480
Waterbury	73,141		13,836
Evansville	69,647		2,759
Norfolk	67,452		10,256
Ft. Wayne	63,933		10,260
Terre Haute	58,157		21,600
Johnstown	55,482		10,300
Jacksonville	57,699		5,958
Covington	53,270		5,160
South Bend	53,684		10,527

Incinerators.(continued)

City	Population	Tons of Dead Animals Burned	Cubic Yards Garbage Burned Annually.
Allentown	51,913		8,750
Canton	50,217		5,360
Lancaster, Pa.	47,227		7,200
McKeesport	42,694		4,627
Wheeling	41,641		10,527

It would be of interest in this connection to see just where the garbage reduction plant makes its profit in the disposal of garbage. It is obvious that no private plant will publish cost data covering its entire plant, and therefore we must turn to municipal plants for our information in regard to cost. As has been noted, the only municipal plants reducing garbage are at Cleveland and Columbus, Ohio. Reports of these two plants are given on pages twenty-five and twenty-six.

The report of the Milwaukee incinerator as given in Bulletin #5 of the Milwaukee Bureau of Economy and Efficiency, offers a good comparison. This report only covers a period of three months but since the data is in cost per ton of garbage burned, the three month period is as useful as the twelve month period.

Month	Direct Furnace Labor	Indirect Labor	Depreciation	Plant Expense	Maintenance	Insurance	Interest Taxes Rental
January	$1.435	$.5237	$.3829	$.0216	$.1400	$.0371	$.5466
February	1.239	.5120	.3856	.0218	.1411	.0273	.5506
March	1.296	.4979	.3502	.0200	.1281	.0248	.5000

Totals:	January	$3.076
	February	2.877
	March	2.817

THE CLEVELAND REDUCTION PLANT.

Engineering News. Nov. 1911

	1905	1906	1907	1908	1909	1910
Population	468,000	486,000	506,000	525,000	543,000	560,663
Garbage Collected, tons	30,382	34,891	37,606	41,247	44,590	44,747
Tons per capita per year	0.065	0.072	0.074	0.079	0.082	0.080
Total cost of works to end of year.	$70,495	85,328	190,830	223,782	225,551	232,108
		COST PER TON.				
Labor	$0.880	$1.253	$1.175	$1.106	$0.906	$0.973
Coal	.361	.573	.435	.090	.021	.102
Natural Gas				.480	.552	.462
Supt. & Clerk	.128	.096	.093	.096	.090	.085
Rep. & Renewals	.234	.136	.214	.186	.252	.163
Press Cloths	.042	.074	.084	.020		
Press Racks	.008	.023	.026	.008		
Insurance	.011	.008	.005	.008		
Office Supplies	.004	.004	.010	.009	.009	.004
Misc. Expenses	.063	.147	.142	.118	.080	.049
Taxes		.010	.012	.016	.016	
Commission Analyses, etc.		.024	.013	.007	.008	.012
Freight	.061	.042	.059	.016	.	.003
Gasoline					.056	.053
Unclassified	.014	.002	.005	.017	.002	.005
Total	$1.896	2.392	2.273	2.177	1.992	1.911
		TOTAL NET INCOME.				
Per Ton	$ -0.022	0.409	0.273	0.714	1.033	1.761

Columbus, Ohio. Reduction Plant.

	1911	1912
Garbage reduced	17,534.5 tons	18,789.5 tons
Expenditures.		
Supervision and Labor	$21,680.58	$24,170.86
Coal	5,964.58	7,443.73
Electric Power	1,921.45	1,305.95
Repairs and Renewals	1,305.36	1,717.73
Supplies	882.26	3,163.09
Office Expense	271.21	181.01
Chemical Analysis	290.45	223.00
Miscellaneous	166.37	299.32
Total	32,482.26	38,503.69
Receipts from Products.		
Grease	34,324.54	42,559.52
Tankage	23,163.69	17,537.04
Hide	1,217.07	1,544.49
Miscellaneous	16.50	87.57
Total	58,721.75	61,728.62
Receipts over Expenditures	26,239.49	23,224.93
Revenue per ton garbage reduced	3.35	3.29
Operating cost per ton	1.85	2.05
	1.50	1.24

Even though these figures show the advantage of the reduction system over the incineration system, it is a fact that the municipal incinerator is much more popular than the municipal reduction plant. This popularity can be accounted for in the following way.

When it became necessary for American cities to destroy their garbage, they naturally turned to European cities for methods of disposal. The main system in Europe was the incineration system. The fathers of American garbage disposal probably felt that burning was the most natural way to dispose of any organic nuisance; and since the European practice was to burn the garbage, that should also be the American practice. The first municipal garbage plant in the United States was an incinerator. Naturally, new municipal projects will get much advertising, especially in magazines having a circulation among people interested in municipal problems. In the early years of the garbage problem in the United States there was much literature about incineration and very little about reduction. There is always a tendency in solving city problems, to follow the lead of other cities. That is why the incinerator has become so popular as a municipal plant. But at the same time there have been private disposal plants springing up all over the country. Ninety percent of these private plants are reduction plants. These plants have received very little advertisement in the municipal or popular magazines, because the individuals owning the plants were loath to disclose their secrets and their financial affairs. Magazine articles must have special features such as special devices for economy, financial statements, cost data, and other features which individuals do not care to disclose. Strange as it may seem, the number of reduc-

tion plants grew until there were as many reduction plants as incinerators in 1909. Now practically all the incinerators are municipal plants, and practically all the reduction plants are private plants.

Usually, when one city has tried some plan, other cities will accept that same plan for no better reason than that it is considered successful in that one city. When an individual, or a private concern, is considering a proposition, he looks carefully into the possibilities for profit and he does not go ahead until he is sure that these profits are assured. Since the reduction system is at least as sanitary as the incineration system, the only basis of comparison left is economy. There is not a municipality which makes a profit on disposal through incineration; the two municipal reduction plants are making a profit on garbage disposal. Each of the private reduction plants must either be making a profit on the garbage treated, or it must be receiving compensation from the city for its work. It is known that a number of the plants are buying the garbage from the cities where they are located. It is also known that if a city was paying more to a private plant than it would cost to run a municipal plant, the city would in most cases dispose of the garbage itself. Therefore, a just conclusionis that the cost to a private company for disposing garbage, is less than to the city, and that the private company is disposing of garbage for a profit. Since practically all the private plants are reduction plants, the reduction plant must be the more economical, and therefore the more desireable plant.

Much investigation of garbage plants is now being carried out, both by municipalities and by private engineering companies.

The results of the investigations made public in the past four or five years favor the reduction method of garbage disposal. It is a system which has much in its favor. Aside from being a sanitary and economical system, it is one which will be favorably commented on by most people after they understand it. When it becomes more widely advertised and more widely known, the layman will be in favor of reduction because it furnishes valuable by-products and can be run at a profit. The press is full of conservation, and when the layman realizes that burning is waste and that reduction is saving, he will be impressed by the conservation of material made possible by the reduction system. Another point which appeals to the layman is the use of the by-products. Much has been written about the economy of the use of by-products, and the reduction system is one whose worth is due to the use made of them. With these two points favoring reduction, a little judicious advertising should make the reduction system popular. Such a plan of advertising has been adopted by engineering companies interested in garbage reduction apparatus. The results of this plan will probably be a marked increase in the number of municipal garbage reduction plants in the next decade.

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